Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

A TECHNICAL STUDY OF INSECTS AFFECTING THE SYCAMORE TREE IN SOUTHERN CALIFORNIA

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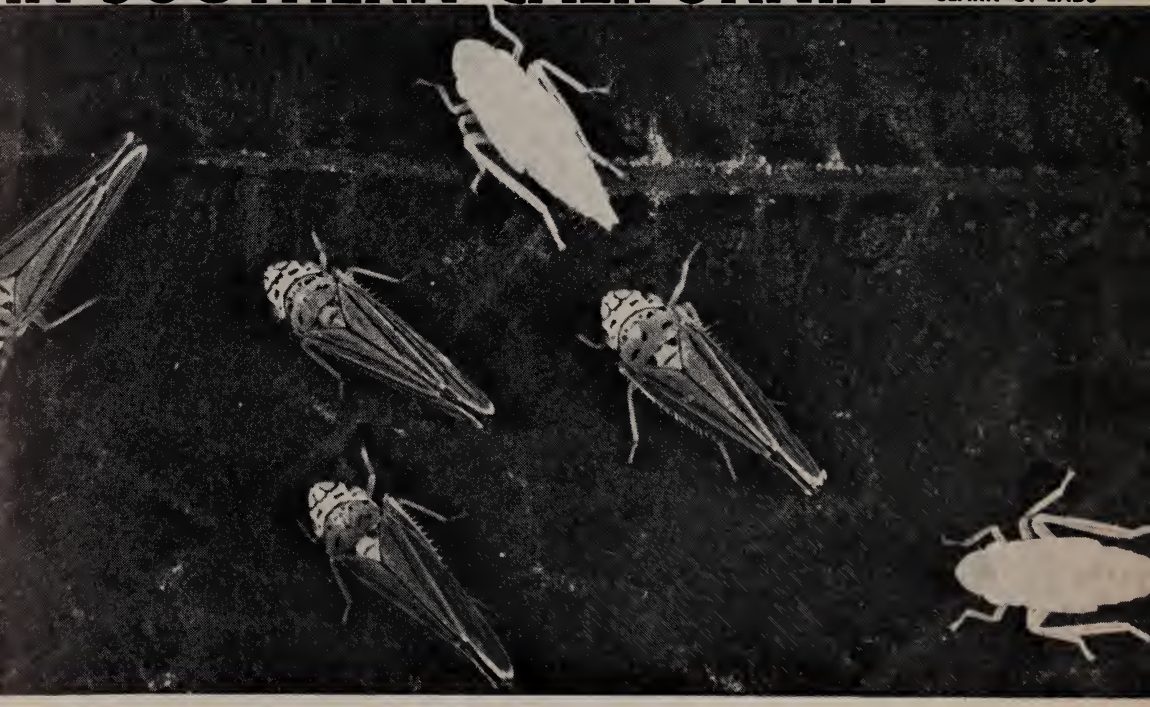

CALIFORNIA AGRICULTURAL EXPERIMENT STATION

BULLETIN 818

HOW TO USE THIS BULLETIN

For the person not trained as an entomologist, a few suggestions may be helpful.

First: Identify the insect or its damage to the sycamore tree. Compare the insect at hand with the main categories in the Contents. Use the photographs to assist in this identification.

Second: Read about the insect on the indicated page in the text. This should confirm the identity as well as supply interesting points about the insect's habits and necessary information on control.

Third: Specific directions to combat the insect begin on page 34.

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OCTOBER, 1965

A Technical Study of Insects Affecting the Sycamore Tree in Southern California[1, 2]

Leland R. Brown and Clark O. Eads

The sycamore, or plane tree (*Platanus* species) is popular in southern California, and is second perhaps only to the oak tree. This huge, white-trunked tree, with the very large maple-like leaves, is a picturesque feature in the landscaping of many homes and parks. The trunk and massive limbs, growing in curves and contorted or gnarled shapes, has often prompted people to plant the sycamore in clumps of three or four trees—as has been done with the birch tree, but in a more massive setting. One popular feature is that the sycamore is deciduous—it sheds its leaves, so that around a home or patio the warming winter sun can come through the tree, but the hot summer sun is kept out by the dense foliage. Our native sycamore, *Platanus racemosa,* is widely used for landscaping, but is also found growing wild along the natural water drainage areas of our foothills and valleys.

Mathias and McClintock (1963) list four species of sycamore grown for ornament and shade in California:

Platanus racemosa Nutt., western sycamore, California sycamore;

Platanus occidentalis L., American sycamore;

Platanus orientalis L., European sycamore, oriental plane tree;

Platanus × *acerifolia* (Ait.) Willd., London plane tree (a hybrid cross between *occidentalis* and *orientalis*).

The sycamore is very durable and can withstand considerable abuse from man and attacks by many insects. The relatively few insects reported in this bulletin are those most likely to be found in southern California and on which original research was done. Many other insects are reported in the literature (Essig, 1958, for example) as attacking the sycamore. We have never encountered a dead sycamore tree whose death could be said, with certainty, to be caused by insects. The insects discussed in the following pages generally may retard tree growth, and in most cases, their attacks will decrease the ornamental or shade values of the tree.

NOTE: For a general discussion of sucking, leaf-consuming, and boring insects, and of the principles and practices of treating large shade trees with insecticides, see the first bulletin (on oak insects) of this series on insects affecting shade and ornamental trees and shrubs (Brown and Eads, 1965).

[1] Submitted for publication October 20, 1964.

[2] The authors began these studies on the Los Angeles campus of the University of California in 1949 and continued them on the Riverside campus beginning in 1960.

Fig. 1. Oystershell scale. Adult females on twigs. (×12.8)

SUCKING INSECTS

Oystershell scale

Oystershell scale, *Lepidosaphes ulmi* (Linnaeus), (Homoptera: Diaspididae), is a common, widespread, and widely described insect pest. It has no particular preference for the sycamore tree, but may be found occasionally infesting it. Essig (1958) lists 97 host plants, of widely diverse families, on which the oystershell scale has occurred. Ferris (1937) states that it may be found on almost any plant, with the possible exception of the conifers. We have found it on sycamores and many other plants throughout southern California. It occurs primarily on the bark, but has also been recorded on the leaves. The scale seems to thrive on the bark of shoots, one to three years old, and sometimes is so numerous that it completely covers the shoots. It sucks the sap and seriously devitalizes the plant, and may cause twigs or branches to die. When it first begins to feed, the tissue around the scale reddens as if it were ripening.

According to Ferris (1937) only females are known, but Quaintance (1916) suggests that there is a male. The armor of this scale insect (figure 1) resembles, as the common name suggests, the shell or one valve of an oyster; it is elongate and spoon-shaped, with fine grooves arching across, giving the appearance of finely-woven, shining silk. The armor usually is light to dark brown. The cast skins of the first and second instar are at the older or pointed end of the armor. The mature armor varies in length from 1.5 to 3.0 mm and is more or less straight, but under conditions of crowding may curve.

Essig (1958) states that the scale passes the winter in the egg stage, under the female armor (see upper right specimen in figure 1), and that hatching crawlers appear in May and June. He notes only a single brood annually. But Quaintance (1916) suggests that there are two broods for southern areas. Control by insecticides, as with other armored scales, is best achieved when the crawlers are hatching or shortly thereafter. Dormant oil sprays have been suggested for controlling this scale insect on orchard crops, but on ornamentals in southern California, combination sprays of oil and malathion, or oil and Diazinon shortly after crawlers hatch are quite adequate. See section on control.

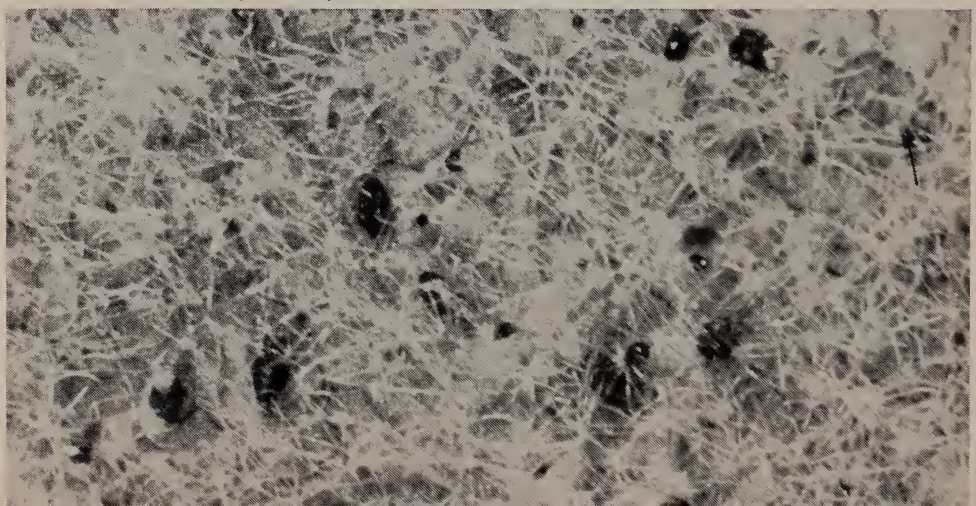
Western sycamore lacebug

The western sycamore lacebug, *Corythucha confraterna* Gibson, (Hemiptera: Tingidae), is found occasionally in southern California, and is particularly noticeable in the late summer. Its outbreaks are sporadic from year to year, and in some years it has not been found. From a distance, the infested tree appears brownish and somewhat wilted and the damage can be confused with a severe mite infestation. The severely infested tree will have lost many of its leaves later in the season. On closer inspection, some leaves appear brown and dead, while neighboring leaves retain their normal green. On the lower sides of the affected leaves large colonies of this gregarious insect can be found, usually many of the immature stages, their cast skins, and a few adults, as in figure 3. Many droplets of dark fecal fluid adhere to the mat of leaf hairs typical of the western sycamore. The portion of the leaf beneath the colony turns brown and dies from the continual sucking of sap by this bug, then the colony gradually shifts to another portion of the leaf and repeats the process until the whole leaf is dead.

The adult (figure 4), having wings, roams from the colony, even to the top surface of the leaf, and spreads the infestation by flying to other leaves to lay eggs in the lower sides of the leaf tissue (figure 2). The adult may drop from the leaf if the leaf is jarred. The dark brown spindle-shaped eggs are inserted about half their length into the lower leaf tissue; at the outer end the egg has a round lid through which the young hatches. The immature are contrastingly marked with black and white, the black being very prominent on the glistening abdomen, which has a noticeable white serrated or spined margin. Two prominent marginal black spots are on the thorax, and the head and part of the prothorax are black; the remainder of the immature is white. The adult (figure 4) is delicately white, lace-like, with a prominent dark brown spot near the middle of each anterior wing, and with other lighter brown markings on the thorax. The thorax has a lace-like expansion extending almost as far out as the lace-like, semi-transparent forewings, while the prothorax forms a hood extending over the head. This lace-like pattern of the lacebugs obliterates the normal wing vein pattern found in most winged insects. The adult is about 3 mm long.

The adult lacebug is said to hibernate during the winter under the bark plates (Smith, 1944). Herrick (1935) suggests that there may be two to three annual generations for a closely related species (*Corythucha ciliata*). Thorough-coverage sprays of malathion during the height of infestation in late summer have yielded excellent control of the western sycamore lacebug. See section on control.

Fig. 2. Western sycamore lacebug. Eggs and egg shells inserted into lower leaf surface of western sycamore. Shiny, dark spots are excrement. (×26.5)



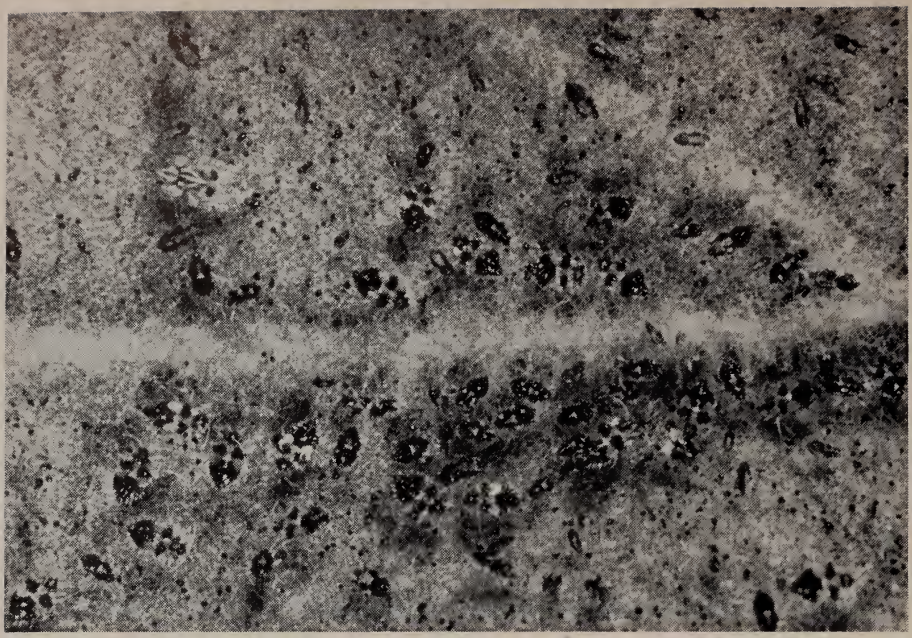


Fig. 3. Western sycamore lacebug. Immature forms and one adult (upper left) on lower leaf surface. (×4.4)

Fig. 4. Adult western sycamore lacebug, showing characteristic lace design. (×17.8)

Blue-green sharpshooter

The blue-green sharpshooter, *Neokolla circellata* (Baker), (Homoptera: Cicadellidae), has a wide host range. It was found on the sycamore but does not seem to be very injurious to it. Smith (1944) indicates that there are six leafhopper species attacking western sycamores, but does not identify them. Typical leafhopper injury to a sycamore leaf can be seen in the left half of figure 12. Leafhopper feeding causes numerous distinct chlorophyll-less spots, each much larger than the feeding site of an individual mite and with much less chlorophyll remaining than from mite feeding. The leaf turns yellow and, if the infestation is heavy enough, becomes dehydrated and brittle; eventually necrosis, or browning, of the leaf occurs. From a distance the damage is much like that of lacebug.

The blue-green sharpshooter adult is, as Baker (1898) stated, one of the prettiest of such insects (figure 5). The forewings are dark blue, and thorax and head lighter blue, and the triangular scutellum, certain spots on the head, and the legs, are bright yellow; an artist could hardly select more pleasing complementary colors. The arrangement of the black spots on the head and thorax is specific—it is like that on no other leafhopper. The wing veins are dark. The adult is slightly longer than 6 mm. Like all leafhoppers, it has a streamlined shape and a double row of spines on the hind tibia. The immature stage (figure 5) is a translucent white with a slight tinge of yellow on the abdomen.

The ability of leafhoppers, including this one, to move sideways and to the opposite side of the leaf from the observer is well known. Note also in figure 5 the leafhoppers' parallel orientation to each other, which is a common reaction. Severin (1949) gives a complete account of the life cycle of *Neokolla circellata* on grape—a more favored host than sycamore—in the Berkeley area of northern California. Oviposition occurs by the laying of a single egg in a slit in the leaf petiole. Severin indicates that this leafhopper usually has only a single generation annually, but may have a partial second brood in some years. Control of leafhoppers is usually attempted when their presence or damage is noted, which means during the foliage season. A number of insecticides will give good control of leafhoppers, such as DDT, Sevin (carbaryl), malathion, Diazinon, etc. See section on control.

Fig. 5. Blue-green sharpshooter. Adults and immature form on a leaf (×4.4)

Sycamore scale

Year after year the sycamore scale, *Stomacoccus platani* Ferris, (Homoptera: Margarodidae), is perhaps the most important insect pest of the sycamore tree in this area. It is a native insect and seriously infests not only our native sycamore, *Platanus racemosa,* but all other plane trees imported into this area, such as the American sycamore, *P. occidentalis* (Smith, 1941, notes this species least affected), the European or oriental plane tree, *P. orientalis,* and the hybrid of the latter two species: the London plane tree, *P.* × *acerifolia.* The last tree, because of the scurfy nature of its bark (figure 7), often harbors enormous populations of the sycamore scale, and is prone to much injury from them. Much harm is done to our *P. racemosa,* but there are definite clonal differences within this tree species, that is, some specimens of this tree appear to have fewer scales, or are affected less by the scale, than other specimens. Cuttings have been propagated from these apparently more resistant strains and introduced into the nursery trade; the reader interested in this subject should consult his nurseryman.

Injury is most apparent on the leaves (figure 6), with the appearance of numerous small yellow spots. Feeding in the center of each of these spots, almost always on the lower leaf surface, is the female scale (figure 11). These spots gradually turn brown and die. When this happens on leaves in the process of growing, as in the spring, the subsequent growth causes the infested leaf to become distorted (figure 6) and smaller than similar uninfested leaves. If the leaf has attained its growth, as later in the season, before the spots become necrotic then such distortion will not occur. Such infested and spotted leaves may drop off long before they would fall if uninfested, sometimes to the extent, as stated by Smith (1944) concerning sycamore-planted parkways, that "street crews are maintained more or less continually in service to remove fallen leaves from along the streets." The scale may secrete some toxin, for apparently only a relatively few scales feeding on the leaf petiole can cause the leaf to drop. A less obvious type of injury, more difficult to assess but un-

Sycamore scale. Fig. 6 (below). Four older leaves at left injured by scale; terminal leaves at right escaped injury.

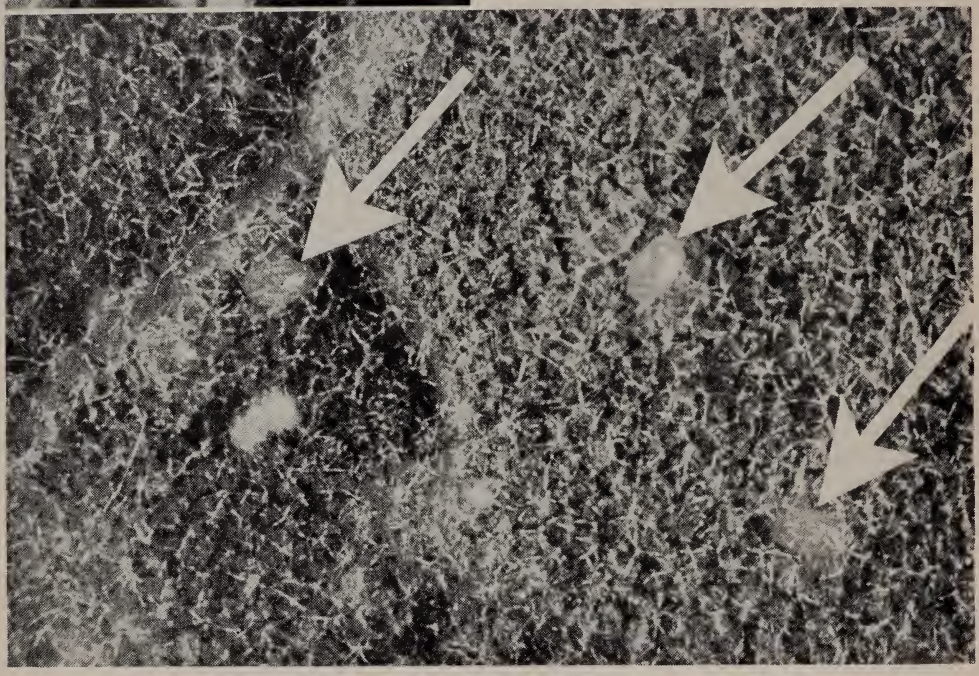
Fig. 7 (opposite, top). Heavy scale infestation indicated by cottony masses protruding from fissures in bark.

Fig. 8, opposite, center). Numerous cast skins of females on bark—a warning of harmful infestation. (×5.2)

Fig. 9 (opposite, bottom). Eggs hidden in cottony masses under bark plates of sycamore limb. (×75.0) (Photos, figs. 6 and 7, by R. H. Smith.)

Fig. 10 (left). Second instar of sycamore scale on leaf bud of London plane tree. (×28.8)

Fig. 11 (below). Third instar females (arrows) on lower leaf surface. Single cottony mass (lower left) is cocoon of male. (×13.9)



doubtedly important, is the feeding on the tender bark of the limbs and twigs. When the scale is as numerous as shown in figure 8, the feeding injury can be harmful to the tree.

Ferris (1917), in the original description, notes a few aspects of biology and life history. Burke (1938) adds several more aspects. Smith, in his several papers (1941, 1944, 1945), presents rather detailed and complete information on life history, biology, seasonal history, as well as insecticidal control information. Our observations have confirmed the studies of these workers in almost all respects. We are fortunate to have fallen heir to the late Professor Smith's notes and microscope slides.

Ferris (1917), in erecting this new genus and species, noted that the Margarodidae differs from other Coccoid families by the presence of legs in the first instar, their loss in subsequent instars, and their reappearance in the final or adult instar. The genus *Stomacoccus* is further distinguished from other Margarodids by the presence of mouthparts in the adult female. In contrast to the cottony cushion scale, *Icerya purchasi*, one of our larger Coccoid scales, the sycamore scale is one of the smallest of the scale insects. So the Margarodidae may be further characterized by the great diversity in size of its members.

The adult female of the sycamore scale (fifth instar) grossly resembles an immature thrips: it is wingless, with legs, and about 1.6 mm long. She possesses the

long hair-like mouthparts of the Coccoids, is yellow, brownish-yellow, or brown, and her tarsal claw has at least six distally knobbed hairs arising near its base. She secretes cottony wax from a few wax glands near the anal end of her body. The adult male sycamore scale is likewise grossly similar to an immature thrips, but is much more slender than the female. Being wingless he differs from other Margarodids, such as the cottony cushion scale whose males are winged. He also evidently possesses wax glands as part of his life is spent in a cottony cocoon (figure 11).

The newly-hatched first instar of the female sycamore scale is very much like the crawler of other scales: it is mobile, oval in outline, and somewhat dorso-ventrally flattened. Later this first instar attaches itself by its mouthparts to the plant, molts to the second instar, and becomes football-shaped; the legs are shed, and many minute strands of white wax are secreted from the margins of the body. The second instar (figure 10) appears somewhat like an immature whitefly. The third instar (figure 11) of the female, looks like the minute egg of an insect—ovoid, yellow or yellow-brown, and with no apparent appendages; her only attachment to the plant is by her mouthparts which have been inserted into the tissue. Sometimes this third instar may show remnants of the wax fringe of the second instar. The fourth instar is like a pupal instar and is evidently a pharate instar in which the fourth instar is inside the exoskeleton of the third instar. Thus, externally, the fourth instar appears as those in figure 11, but internally the legs are developing. The fifth female instar is the thrips-like adult mentioned above. Smith (1941) indicates that the development of the male is more complicated, although only five instars are noted. Part of its cycle is spent within the cottony cocoon, as mentioned.

There may be from three to five generations annually, with all the scales being at the same stage in early January, that is, first or second instar, as shown in figure 10, on the bark and under the bark plates. By about mid-February most of the scales mature and the females begin to secrete the masses of cottony wax, as in figure 7, and begin their egg-laying (figure 9) in these masses under the bark plates. About the time the sycamore leaves have pushed out from the buds these eggs hatch and the young crawlers migrate to the tender areas of the bark, as in figure 8, and the leaf buds, leaf petioles and leaf blades, as in figure 11. Development proceeds in these locations with the leaves becoming distorted as in figure 6. Upon attaining adulthood and legs, the males and females mate on the leaf and the females migrate back to underneath the bark plates, secrete more cottony wax and lay eggs. Each female lays from 50 to 100 eggs. The terminal leaves in figure 6 evidently expanded while the scales were back at the bark plates laying eggs, and thus escaped the distorting type of injury. The eggs of this next generation hatch and migrate back to the leaves, distorting those leaves not fully expanded and causing only the necrotic spots on the fully expanded leaves. This cycle is repeated one to three more times during the year, with some of the egg-laying occurring in cottony masses on the leaves near the major leaf veins. Some scales complete their development more rapidly than others, thus accounting for the five generations annually for some, four for others, and only three for the remainder. These facts account for the considerable overlapping of broods in the last half of the year.

The first or second instar during the winter months, particularly in January, is a diapausing or resting stage, with all the scales being in this stage for a relatively long period. At no other time of the year is the development of this scale so well synchronized. Considerable experience has shown that this stage of the scale is very susceptible to insecticides, more so than other instars of the scale. The sycamore tree in the dormant, leafless period is much easier to spray, and much less spray material is required per tree. Later, the presence of leaves means more surface to spray with more material, and a more expert technique to cover the undersides of the leaves. Also, the scale is

then at a more insecticide-resistant stage, beneath the mat of entwining, stellate leaf hairs which are common on the lower leaf surface, especially on our native tree. These hairs are particularly difficult to wet, causing spray droplets to remain as droplets attached to the outside of the hair mat, as water droplets do when sprayed on wool cloth. All these facts together indicate that the best time to spray for the scale is early January. If the spray is delayed by as little as mid-February, many of the scales will be mature, with the females under the bark plates secreting the cottony wax and laying eggs within it; this cottony wax is particularly difficult to wet also. Even though January is the best time to spray for the sycamore scale, the scale and its injury are then at their least conspicuous stage. Or, stating it differently, when the scale infestation is most obvious (during summer), control is most difficult.

A number of insecticides are effective against the sycamore scale. A dormant oil spray—an old recommendation—is still good; use at the rate of 3 per cent, that is, 3 gallons of dormant spray oil with 97 gallons of water. Oil sprays in combination with some of the synthetic organic insecticides (Brown and Eads, 1951) are also effective; use a light medium grade oil, at 1½ gallons with 98½ gallons of water, in combination with 1 pound of active ingredient of any one of the following: toxaphene, DDT, BHC, malathion, or Diazinon. In a recent experiment control with Diazinon alone (without oil) was excellent.

In spraying a sycamore tree in January it is important to have adequate spray pressure (at least 500 pounds per square inch), adequate volume of spray delivery (20 to 50 gallons per minute, the higher the better), and to have a good technique with the spray gun. It is particularly important to shoot the spray under the bark plates of the trunk and larger limbs and to get a thorough spray deposit on the smaller limbs and twigs (where there are no bark plates) at the periphery of the tree. It may be necessary to walk under the tree with the spray gun almost to the trunk. The spray flowing down the trunk will get beneath the bark plates from the top. The addition of 4 ounces of a wetting agent, or spreader-sticker, per 100 gallons of spray will facilitate the wetting of the scales beneath the bark plates in some difficult situations. See section on control.

Sycamore spider mite

There is some confusion in the literature regarding tetranychid mites that attack the sycamore tree in California. Burke (1938) notes that the most injurious pests of sycamore in central California are two closely related red spider mites: the common red spider, *Tetranychus telarius* (Linneaus), and the Pacific red spider, *T. pacificus* McGregor. Smith (1939, 1943, 1944) discusses the southern red mite (ilicis mite), *Paratetranychus ilicis* (McGregor) as a universal pest of all species of sycamore trees throughout California; Smith notes that McGregor made his determinations for him. McGregor in 1950 evidently realized that what was being called *ilicis* on California sycamores was in reality a new species and named it *Paratetranychus platani*. Pritchard and Baker (1955) accepted McGregor's distinction between *ilicis* and *platani* but placed them in a different genus: *Oligonychus*. There is little doubt in our minds that the major spider mite pest on sycamores in California that has been called *telarius* or *ilicis* is in reality *Oligonychus platani* (McGregor), (Acarina: Tetranychidae), and all that has been written on the first two species, with respect to California sycamores, should be referred to *platani*. There is not much morphological difference between *ilicis* and *platani*. The differences in body color, host preferences and collection sites, as noted by Pritchard and Baker, are quite obvious however. "Sycamore spider mite" (referring only to *O. platani* (McG.) with no mention of red color, and considering its importance

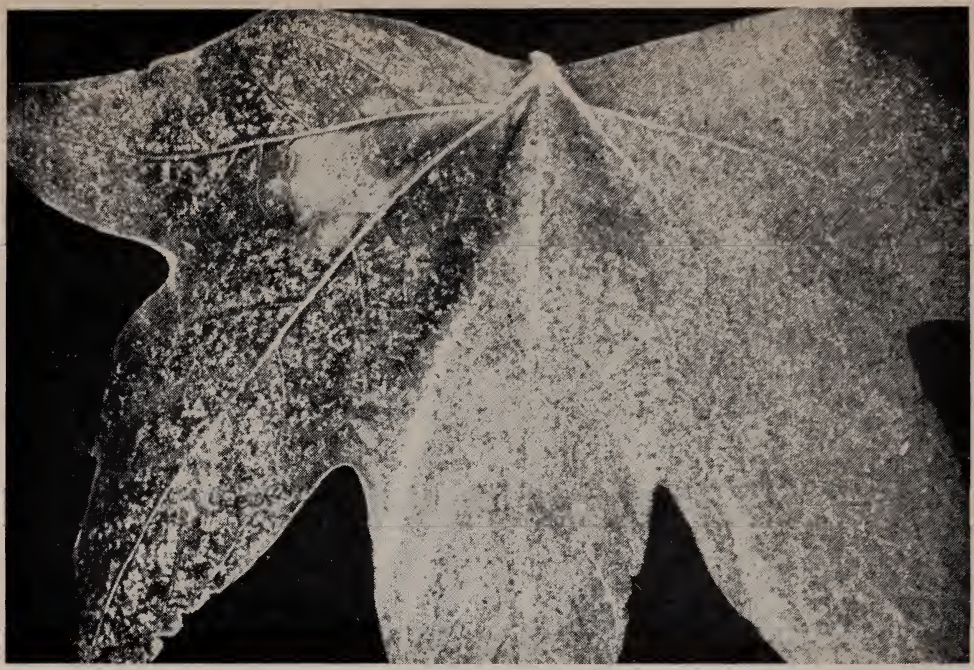


Fig. 12. Right half of western sycamore leaf damaged by sycamore spider mite. Larger stippling on left is leafhopper damage. (×0.75)

Fig. 13. Sycamore spider mite. Adults and cast skins on a leaf. (×26.4)

to this tree) seems an appropriate new common name. *O. platani* also infests several oaks and some rosaceous ornamentals in this area.

All that Burke, Smith, and Pritchard and Baker have written about the seriousness of this spider mite to California sycamores is certainly true in our experience in southern California, not only in the hot, interior valleys, but also the coastal districts. The mite does appear to thrive during hot weather wherever it is found. From a distance the heavily injured sycamore has a brownish-bronze appearance. On the individual leaf (figure 12, right side) the chlorophyll appears to be completely removed from the palisade cell layer. The leaf in figure 12 is unusual in that most of the left half was shaded, thus perhaps suiting the needs of leafhoppers whose feeding injury can be seen, while the right half was in the direct sun, a more suitable site for spider mites. In such cases puncturing of almost all the upper epidermal cells of the leaf results in severe dehydration of the leaf. Mite infestations appear to start along the veins on the upper leaf surface, or in any other depression of the surface; this is evidenced by the numerous whitish cast skins and empty egg shells in these areas. Eventually the whole top of the leaf blade is fed upon and cast skins and egg shells may be found over all the top leaf surfaces.

The adult female mite (figure 13, center) is sometimes dark green or olive green, being of paler color forward and along the margins; the legs are pale greenish-yellow. According to Pritchard and Baker (1955) the female has seven tactile setae on the first tibia and 3 tactile setae proximally from the duplex setae on the first tarsus. Body length is about 1/3 mm. The males are not so rotund as the females, shorter, and tend to be reddish or reddish brown. The egg is yellowish white, with a central stipe and faint striations radiating from the stipe. Some webbing is spun but on the whole it is quite inconspicuous. Smith (1944) notes that the female mites abandon the leaves in the fall, overwinter on vegetation surrounding the trees, and move back on the sycamore when the leaves appear in the spring. Breeding is continuous throughout the summer with perhaps as many as 10 to 12 broods (Burke, 1938) occurring during the year.

Control of spider mites can be accomplished with the following acaracides: Aramite, Kelthane, Tedion or Chlorobenzilate. Spray when first noticed. Either oil-Diazinon spray, particularly, or oil-malathion spray, applied in the dormant spray for sycamore scale control, will result in less mite bronzing of leaves in summer. See section on control.

LEAF-CONSUMING INSECTS

Sycamore leaf blotch miner

The sycamore leaf blotch miner, *Lithocolletis felinella* (Heinrich), (Lepidoptera: Gracilariidae), is one of the two common leafmining insects affecting the sycamore in southern California; the other is the sycamore leafmining sawfly, *Profenusa platanae* (see page 19). The blotch miner injury is seldom severe but infestations may be heavy enough to cause considerable defoliation (Burke, 1938). Even without defoliation the numerous mines in the leaves detract from the ornamental value of the tree. The shape of the mines is tent-like, probably because the silk, spun by the larva in the mine, prevents the leaf around and over the mine from expanding normally as the leaf grows. Also, as the larva spins silk across the inside of the mine surface, the silk contracts on drying, forcing the surface up to form a tent-like mine. The mine is apparent from the bottom of the leaf because its color is much lighter than the rest of the leaf, and because it is restricted by the veins (the main veins of the sycamore leaf are in the lower part of the leaf), so that the outline of the mine is angular (figures 14–16). The larva completely removes the spongy mesophyll layer in the mined part of the leaf. From the top of the leaf the mine is less apparent; it is noticeable as many light colored spots which are made by the larva feeding from the spongy mesophyll layer up into the palisade layer of the leaf. Sometimes this feeding removes most of the palisade cells in a portion of the mine, so that a large spot devoid of chlorophyll is apparent on the mine's upper surface. The complete palisade layer of some mines may be removed. Injury done by the blotch miner occurs throughout southern California, and is particularly common on the native sycamore, *Platanus racemosa.*

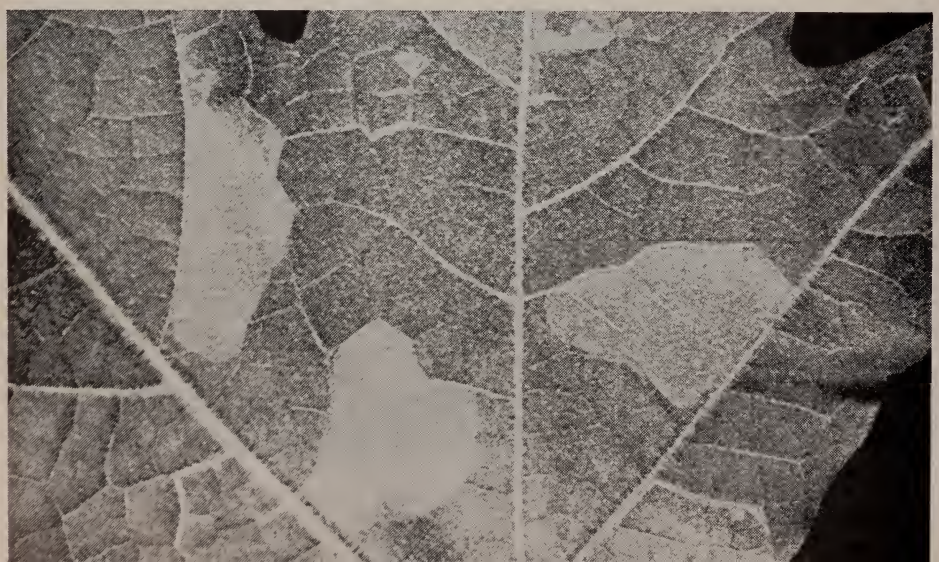
The egg of the blotch miner (figure 17) is 0.25 mm in diameter, and is translucent white; it is convex dorsally, flat ventrally (the side toward the leaf) and distinctly reticulated. Eggs are laid singly on the lower surface of the leaf under the numerous stellate leaf hairs common on that part of the leaf. The larva hatches by boring through the bottom of the egg shell and into the spongy mesophyll layer of the leaf. It begins mining in a linear or serpentine manner, and it is not until a

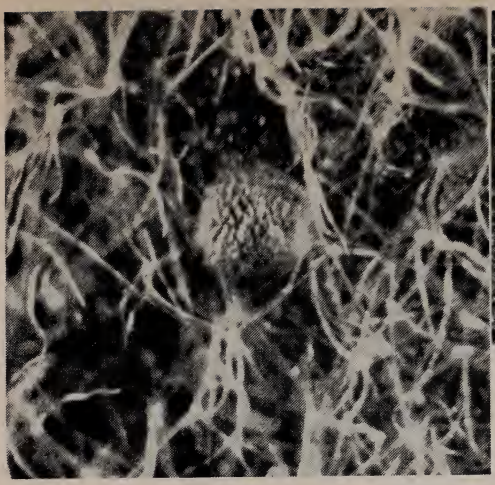
Fig. 14. Mines of sycamore leaf blotch miner (right) and of leafmining sawfly (left). Upper leaf surface at top; lower leaf surface below. (×0.73)

Fig. 15. Mine made by sycamore leaf blotch miner was linear at first, and became blotch-like after contacting large vein at bottom. (×5.1)

leaf vein is contacted that the larva turns and follows along the vein (figure 15). Shortly the larva turns around in the mine and begins feeding out from the border formed by the vein, so that the mine begins to assume a blotch shape. Eventually the mine obliterates the linear first portion and becomes completely blotch-like and angular, as in figure 16, being bordered on all sides by veins. Sometime after this (probably after its head shape becomes so adapted) the larva begins to feed up into the palisade layer of tissue, which is toward the upper surface of the leaf; this feeding causes the lighter colored spots on the upper leaf surface mentioned above. The larva passes through five instars, and when mature (figure 18) is approximately 5 mm long; it is translucent greenish-white to opaque white. The younger instars have a very flat head, with forward projecting jaws; at maturity the head becomes more nearly spherical and the jaws tend to point downward. The younger larval instars, in addition to being quite flat, also have rather pronounced lateral extensions on the segments, especially on the thor-

Fig. 16. Lower leaf surface showing several mines of sycamore leaf blotch miner. Angular outlines bordered by veins are characteristic of injury done by this miner. (×1.1)





Sycamore leaf blotch miner. Fig. 17 (left). Egg under leaf hairs of lower leaf surface. (×67.7) Fig. 18 (right). Larva exposed in mine by removing lower leaf surface. Black granules are fecal pellets. (×8.8)

acic segments. The thoracic legs and prolegs are very rudimentary. The larva as it approaches maturity becomes more cylindrical, and also more tidy in the mine by moving, and tying together with silk, the scattered, blackened and spherical fecal pellets toward the center of the blotch mine. Toward maturity the legs become more apparent and functional. Whitish silk is spun and completely lines the mine. As pupation approaches, the mature larva spins a fence of silk, somewhat oval in outline and joining the upper and lower sides of the mine; this is done in a more spacious, tent-like fold of the mine. Inside of this silken fence the larva spins a flimsy, thin, ovoid, silken cocoon (figure 19), and pupates in it (figure 20). By this time the larva has collected all the fecal pellets into a pile.

Fig. 19. Sycamore leaf blotch miner cocoon exposed in mine. (×14)

Fig. 20. Cocoon showing pupa in mine. Note sharp head for piercing cocoon. (×8.5)

Fig. 21. Pinned and spread adults of sycamore leaf blotch miner. (×5.1)

The pupa is approximately 3.5 mm long, with a smooth, shining surface, and is light brown to darker brown anteriorly; sometimes the lighter parts of the pupa may have a greenish hue. The wing pads of the pupa are long and narrow, free from the body, and extending almost to the posterior end. The head of the pupa is pointed, which is useful when the adult is about to emerge. The pupa, by vigorous wriggling, pushes the head through the flimsy cocoon, and then through the by then dried lower epidermis of the mine. When the anterior part of the pupa projects about a quarter of its length through the epidermis to the outside, the back of the thorax splits and the adult emerges. The adult (figure 21) has a wing expanse of approximately 7.5 mm, with the forewings being a light golden yellow. The forewings have a dark margined basal white streak, and other dorsal and costal whitish streaks that converge toward the center. There are three transverse, whitish streaks and a small dark spot toward the apex. The hind wings are lance-shaped, with a wide fringe of hairs, and pale smoky white. The abdomen is a darker gray. The head has a prominent tuft of pale golden yellow scales projecting forward. After the adults mate the females lay their eggs beneath the leaf hairs, thus completing the life cycle.

There are probably three overlapping broods or generations per year. Some strains vary so that there may be more or fewer generations than this. The insect overwinters as a pupa in the mines of the fallen leaves or in those few dead leaves remaining on the tree. First adult emergence from the previous year's fallen leaves occurs about the time the leaves are fully out of the leaf buds (this may vary from about mid-February through March in southern California). The eggs are laid and the first brood mines are started.

Smith (1944) notes that this insect is periodically controlled by parasites. In addition to Hymenopterous parasites, we have noticed numerous overwintering pupae in the leaves on the ground, killed by some unidentified fungus. Birds, especially the bush tit, *Psaltriparus minimus,* feed upon many of the overwintering pupae. Flocks of from five to twenty of these birds feed quite heavily on the pupae, many in dead leaves still hanging in the tree, others within the leaves on the ground.

One obvious method of alleviating heavy infestations of this insect is to rake and burn the fallen leaves during the winter. A spray of DDT (for the newly-emerged adults), as the sycamores leaf out in the spring, gives good control of this insect. See section on control.

Fig. 22. Severe injury by leafmining sawfly on upper surface of western sycamore leaf. (×0.4)

Sycamore leafmining sawfly

The sycamore leafmining sawfly, *Profenusa platanae* Burks, (Hymenoptera: Tenthredinidae), is the second of the leafminers attacking the sycamore. Both the sawfly and the leaf blotch miner, discussed before, are very common throughout southern California, as well as the rest of California. Until 1956 all leaf mining injury to sycamore and all larvae in these mines were assumed to be of the blotch miner. In that year our studies showed conclusively that two insects were involved: the well-known small moth and an unknown tenthredinid sawfly. At our request B. D. Burks, of the U. S. National Museum, described this new sawfly species (Burks, 1957). As both leaf miners are widely distributed in this state, it is likely that both have been here for many years and may even be native to this region. We have found the sawfly only on the native sycamore, *Platanus racemosa,* although it is possible that it may live on other species also. How these two widely different insects escaped detection of their differences, for many years, is apparent by a comparison of their similarities of habitat, habit and even larval morphology. Although we noted differences before 1956, the first exciting clue that a radically different insect was present, was our discovery that the larva left the mine to pupate—a typical habit of the leafmining sawflies. The larva of the leaf blotch miner remains in the mine to pupate.

A comparison of the leaf mines of the blotch miner and the sawfly may be seen in figure 14. The mine of the sawfly is very apparent from the top of the leaf—especially when it is first forming, whereas that of the blotch miner is most noticeable from the bottom of the leaf. The sawfly mine has typical billowing or rounding contours, and its limitation by the leaf veins is not as apparent as in the angulate mine of the blotch miner. The black, cylindrical fecal pellets, even while the sawfly larva is quite young, are placed toward the center of the mine; this is quite apparent in the upper left mine in figure 14. As the larva gets bigger the mines become larger, as in figure 22, and all of the tissue between the upper and lower leaf epidermis may be consumed, as shown in figure 23. This photograph of the translucent mines also shows the coalescence of several mines that often occurs in a heavily infested leaf; it is not unusual to find six or seven near-mature larvae (or more) in one large, coalesced, blister-like mine, such as in the

Fig. 23. Sawfly larvae and dark fecal pellets in sycamore leaf. Note billowing and coalescing mines not limited by veins. (×0.4)

Fig. 24. Sawfly larva makes linear mine (left) at first, then expands it (right) to a blotch type. Dark fecal pellets are placed in center of mine. (×5.1)

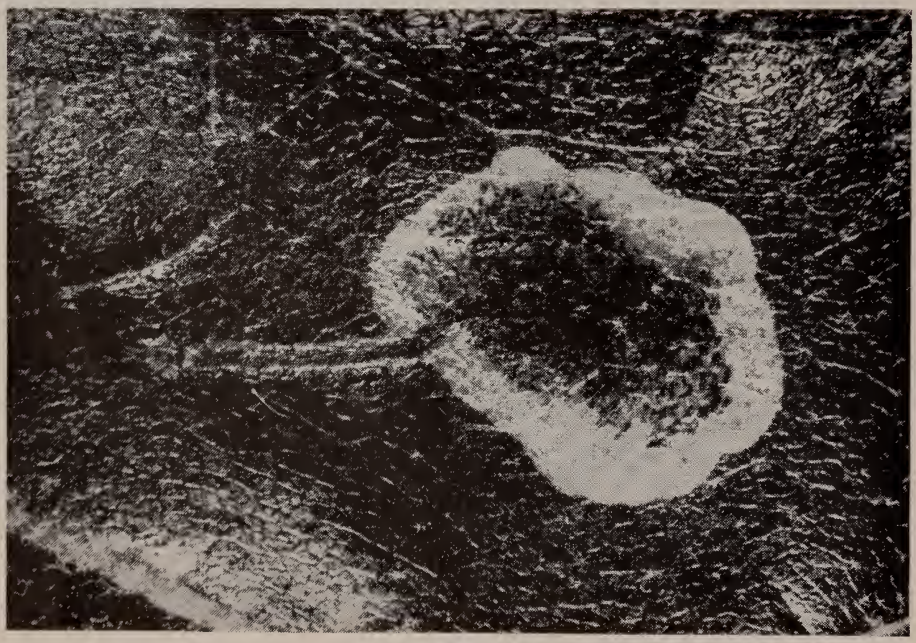


Fig. 25. Arrow points to small opening in upper leaf surface into which egg of sawfly was inserted. Linear mine leads from egg site to the right. (×10.5)

Fig. 26. Lower leaf surface removed to expose newly deposited, moist, glistening sawfly egg (×25.9)

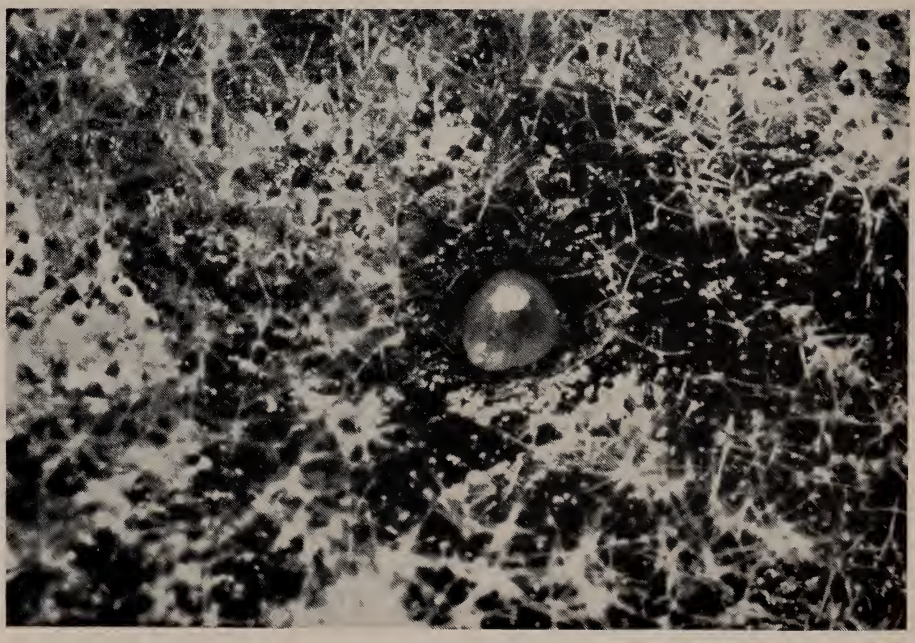


Fig. 27. Four nearly mature sawfly larvae exposed in a single coalesced mine. (×4.1)

lower left of figure 23. In one instance, a leaf contained one mine having 41 larvae in the same mine with a total of 70 larvae mining in the one leaf; another leaf had a total of 95 larvae. Such heavy infestations greatly limit the capacity of the leaf to function normally, and the leaf usually drops long before uninfested leaves. Such infestations detract from the ornamental value of the tree, and the fallen leaves are a nuisance.

The life cycle begins with the insertion of the egg into the leaf from the upper surface of the leaf (figures 25, 26, and 32). The female utilizes her sawlike ovipositor to cut a slit in the leaf and inserts her egg in the slit. Sometimes the egg is inserted almost completely through the leaf blade, with only the lower epidermis of the leaf remaining, so that a small swollen area appears on the bottom of the leaf. The lower epidermis was removed in figure 26 to expose the egg, which is moist, glistening, and translucent yellow, and appears like a minute lima bean, approximately 0.1 mm thick and 0.3 mm long. According to Needham *et al.* (1928) eggs of the sawfly subfamily Fenusinae (includes this *Profenusa*) swell in the leaf to almost twice their size, so that their location is much more apparent in the leaf blade.

After about five days in the egg stage the newly-hatched larva begins mining along the tops of the palisade cells in a narrow, straight or slightly curved mine (figure 25), but soon (at the second instar) voraciously begins to enlarge the mine to a blotch (figure 24). The larva (figure 27) near maturity (sixth instar)

Fig. 28. Opened soil cell of sawfly larva preparing to pupate. (×6.5)

is approximately 9 mm long, with the head slightly more than 1 mm wide and the largest width of the thorax almost 2 mm. Its color is white, the head is light brown and the mouthparts dark brown. The gut and its greenish contents are visible through the dorsum. The bases of the thoracic legs are widely separated, typical of leafmining tenthredinids. According to Needham *et al.* (1928), the single ocellus (simple eye) on either side of the head distinguishes the leafmining sawflies from the leafmining Lepidoptera. The prolegs, although present, are not prominent. There are seven larval instars, six in the leaf and one in the soil where pupation occurs. The larval period in the leaf extends over about 30 days, and then the larva cuts a "C-shaped" slit in leaf epidermis covering the mine, and drops to the soil. Up to the time of cutting the "C" in the mine for emergence, the leaf surfaces are soft and pliable. Soon after the hole is cut, the leaf surfaces dry out and become brittle and dark brown.

The larva burrows two or three inches

into the soil and enlarges its burrow to make an oval cell. This cell is lined with a tough, brownish, paper-like material, probably from the labial glands, with bits of soil and sand incorporated in the lining. In this cell (figure 28) the seventh instar larva assumes a characteristic position and the segments become swollen so that they are rather prominently ring-like. The first generation larvae, and those of succeeding generations, remain in this state for about two weeks before pupation, except the larvae of the last generation in the year, which remain as larvae for several months and do not pupate until very early the next spring. Figure 29 shows the pupa, removed from its soil cell, shortly after the last larval molt; the appendages are free and the compound eye has darkened. Later (figure 30) almost all of the pupa has darkened; the pupa is approximately 5.3 mm long. The pupal stage occupies about two weeks, but counting the seventh larval instar the insect may be in the soil from 30 to 45 days or longer.

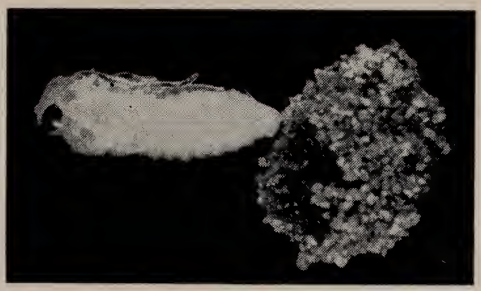


Fig. 29. Newly formed pupa of sawfly removed from its soil cell. (×5.9)

Fig. 30. Soil cell opened to show sawfly pupa shortly before adult emerges. (×5.5)

The adult sawfly emerges in the soil cell, and the wings are fully expanded before the adult chews its way through the cell lining and digs its way to the surface of the soil (figure 31). The body length of the adult female (figure 32) is approximately 4 mm, and the male 3.5 mm. The tegula (small epaulette-like scale overlapping front base of forewing) of the female is mostly yellow, and that of the male mostly black. Otherwise, both sexes are completely black except for the distal ends of the legs (from the apex of the femora outward), which are yellow. The third segment of the antenna is almost twice as long as the remaining eight segments. The tarsal claw is forked and with a large basal lobe. On emerging from the soil the adults clean themselves (figure 31), and then fly to the leaves of the sycamore tree. There they mate, and the female lays her eggs in the leaves, thus completing the life cycle. Although eggs are deposited singly, many such oviposition sites may be found in one leaf.

The adults first appear quite early in the year, mid-February in most areas, and oviposit in the leaves as they are expanding from the leaf buds. The adults appear again in late April and again into late July, these extended and overlapping periods of emergence making it possible to find all stages of the sawfly near the middle of the year. There are from three to five overlapping generations per year. Under optimum conditions some individuals in a generation may take as little as seven weeks to span the egg-to-egg pe-

Fig. 31. Newly emerged adult sawfly cleaning its wings after digging out of the soil. (×8.4)

riod, while others under the same conditions will take 11 weeks. The mature larva of the last generation enters a prolonged period of diapause, remaining as a larva in the pupation cell and then pupating early the next spring. This larval diapause phenomenon evidently is common in the sawflies.

Very good control of the sycamore leafmining sawfly has been obtained with sprays of DDT applied when the leaves are expanding from the leaf buds in the spring. It is an interesting coincidence that this is also an opportune time to control the sycamore leaf blotch miner. See section on control.

Fig. 32. Sycamore leafmining sawfly searching leaf for suitable place to oviposit. (×5.1)

Sycamore leaf skeletonizer

Typical injury of the sycamore leaf skeletonizer, *Gelechia desiliens* Meyrick (Lepidoptera: Gelechiidae), is shown in figure 33. The young larva eats the surface of the leaf, leaving a network of veins, and the older larva consumes portions of the leaf so that holes in the leaf or a ragged appearance of the leaf results. Often these types of injury are so extensive on a tree that it looks ragged, brown and unkempt. We have noticed such damage and infestations only on the native sycamore, *Platanus racemosa*. The insect has been found throughout southern California where this host plant is found; it has also been recorded in other parts of the state (Keifer, 1931).

We have not observed the eggs but, like similar gelechiids, they are probably laid singly on the small twigs and leaves. We have observed adults in every month of the year, even throughout the winter months, so that it is possible that the insect overwinters either in the adult or egg stage. The mature larva (figure 35) is approximately 14 mm long, translucent greenish-white, and with a dorsal darker green stripe, bordered on each side by a narrow white stripe. It is naked except for the few hairs per segment that are in

Fig. 33. Injury typical of skeletonizer on sycamore leaf. (×1.1)

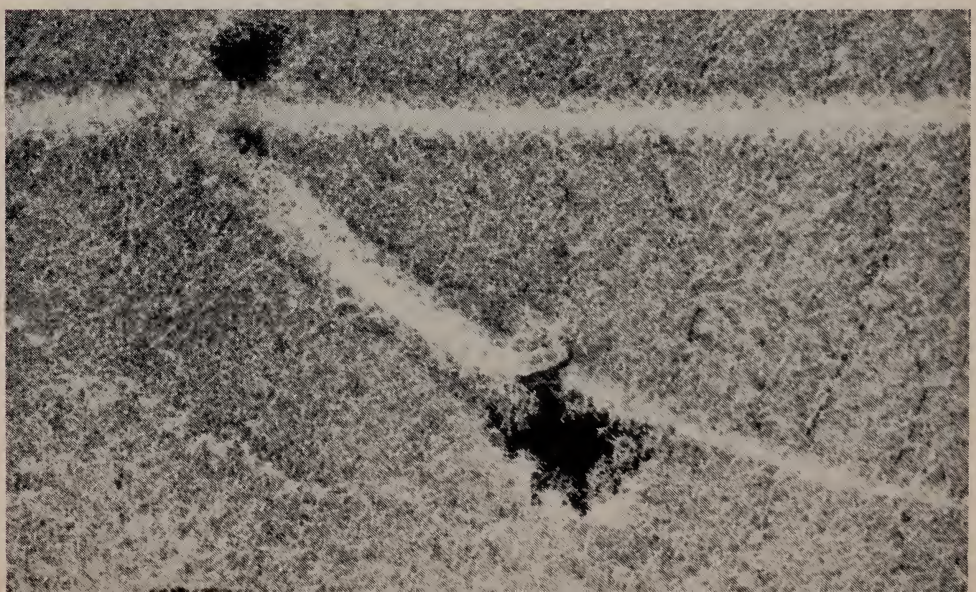
positions typical of gelechiid larvae. The head capsule is a light transparent brown.

An interesting habit of the larva is that it spends most of its larval life in a tubular nest of leaf hairs (figure 34), from which it protrudes the front part of its body to feed. As the photograph shows by the feeding damage, the larva may reverse itself in the tubular nest and feed at either end. Mature larvae may also be found in folds of the leaf, which may be tied together by silk spun by the larva. Some tortricid larvae occasionally tie the leaves and feed therein also. About the only periods the larva is found free on the leaf is when it is gathering leaf hairs on the lower leaf surface for its nest. This gathering is accomplished by its biting off the complex, stellate leaf hair near its attachment to the leaf, and transporting the hair to a linear pile of such hairs. Then by various wriggling movements, even to the extent of butting its head into the pile, it snuggles into the pile of hairs, tying the whole together by a few silken strands. Why the larva exhibits such behavior is unknown, except for the obvious need to have something touching its body (thigmotactic response). The larva usually constructs and abandons several such flimsy, tubular, leafhair nests, in several locations on the leaf, during the larval stage. Even though the larva is not found, its typical feeding injury and these abandoned tubular nests make its identification simple and reliable. Typically the presence of the larvae on the leaves is in the spring—from the time the leaves are fully expanded, in early March, through May.

As pupation approaches, the larva typically may drop from the leaf to the ground, sometimes on a silken thread, and then crawl to and up the trunk and larger limbs, until it has found a suitable site under the bark plates common on this tree. Or, it may crawl from the leaf, down the twigs and limbs to such a site. We have also reared the insect from pupae in folds of the leaves. Under the bark plate the larva spins a kind of cocoon, which is actually like a white silken fence connecting the bark plate and the trunk, to surround an oval area; within this area pupation occurs (figure 36). The pupa is approximately 10 mm long, and has the thorax and abdomen shining mahogany brown; the head, antennae and wing pads are brownish-black. The pupal stage is relatively brief, 10 days to two weeks. After this period the adult emerges after the pupa pierces and protrudes through the silken cocoon.

The adult (figure 37) has about a 20 mm wing span, and the forewings are covered with dark brown scales with a sprinkling of white scales. Also on the forewing are two small black spots near the center and an S-shaped stripe of white scales near the wing apex. The hind

Fig. 34. Young skeletonizer larva feeding from its tubular nest of leaf hairs. (×4.5)



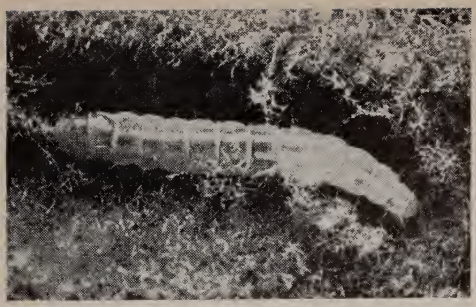


Fig 35. Nearly mature skeletonizer larva gathering leaf hairs for another tubular nest. (×6.9)

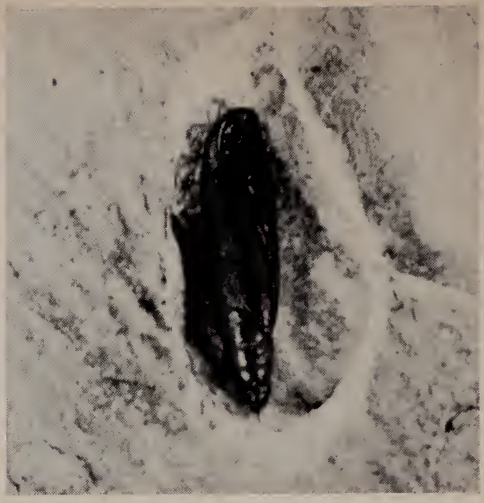


Fig. 36. Skeletonizer pupa in its cocoon beneath bark plates of sycamore trunk. (×5.5)

wings are almost transparent, light brown, but darker on the veins and toward the apex; the fringe is almost as wide as the wing. The wings fold flat over the back at rest. The adults are very secretive, at least during the day when most of our observations have been made, and hide under the bark plates or other crevices of the trunk, or among the shrubbery that may surround the trunk. If disturbed they rapidly fly to the next hiding place and quickly crawl under it. The adults have the curious habit of turning around after finding a hiding place and backing into it. They are commonly found in these locations during June and July but, in fewer numbers also throughout the remainder of the year, even throughout the winter months. There certainly is one generation per year, and possibly two overlapping ones.

Control measures against the sycamore leaf skeletonizer are often warranted. In March, April, or May, or when injury is first noticed, a spray of DDT is quite effective against the larvae. A special effort should be made to cover the undersides of the leaves with the spray. Sevin (carbaryl) is also a very good insecticide for this insect. See section on control.

Fig. 37. Pinned adults of the leaf skeletonizer. (×3.7)

Western swallowtail

The western swallowtail, *Papilio rutulus* Lucas, (Lepidoptera: Papilionidae), is also commonly known as the western tiger swallowtail. It has a very wide host range, attacking many different kinds of woody plants including sycamores. It is only occasionally found attacking the sycamore, and even then it is not a particularly serious pest. The larvae are relatively large and conspicuous, and may be voracious feeders in a localized area of the tree. The adults are very common and showy butterflies, flying during the daytime. We have found it throughout southern California attacking the various species of sycamore.

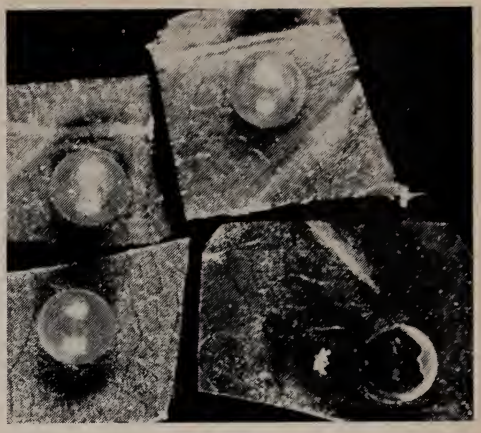


Fig. 38. Western swallowtail eggs and first instar larva. (×5.6)

It is typical of the family that the eggs (figure 38) are laid singly, and are smooth, relatively large—1.7 mm in diameter, opalescent, blue-green spheres, that are somewhat flattened on the side attached to the leaf. Near hatching, the eggs may have faint tints of yellow, orange or red. At hatching the larva chews its way through the side of the egg, and crawls out on the leaf on which it soon begins to feed. At first the larva is very dark brownish black with a white spot near its middle, so that it superficially resembles a bird dropping. The second instar larva (figure 39) has more white showing.

The last, or fifth, instar larva (figure 40) is 35 mm long, and its color is green with a bluish tinge. Small bluish-purple spots are found on most of the abdominal segments. The dorsum of the metathorax has a distinctive pear-shaped, yellow and black spot on each side (appearing like grotesque eyes near pupation, figure 41). It has yellow transverse lines on the dorsum just behind the head and after the first abdominal segment; and the latter line is bordered posteriorly by black. The line just back of the head marks the location of an interesting organ—the osmeterium, a sac that can be turned outward and, when extended (by blood pressure) is a yellowish, two-pronged horn-like organ having a pungent and (to us) sickening odor. It is typical of this family and is probably a protective device used when a bird attempts to grab the larva in its beak. The osmeterium is extended

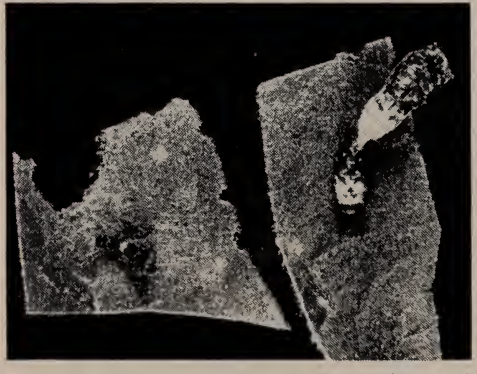


Fig. 39. Western swallowtail first and second instar larvae. (×2.4)

Fig. 40. Western swallowtail mature larva (fifth instar). (×1.5)

Fig. 41. Western swallowtail larva preparing to pupate. Note thin but strong silken girdle extending over larva. (×3.6)

immediately and, by the larva rearing its head back, the organ is brought against the bird's head. The bird, with the presumably sickening, or at least distracting, odor on it, releases the larva.

Before pupation the larva (figure 41) spins a small, silken pad on the leaf, or other nearby support, and close above this a loop of silk (the thoracic yoke or girdle) is spun. The larva attaches its posterior end to the silken pad by the cremaster (a number of minute hooks on its last segment), and wiggles into the silken girdle, so that it surrounds the larva somewhat back of the thorax. This girdle is so strong that if the larva is pulled against it, the larva will be cut in two before the girdle will break. The larva turns its head toward the leaf, as shown, and while the larva is in this attitude of supplication, it turns from green to brown; numerous whitish spots appear

Fig. 42. Ventral, lateral, and dorsal views of western swallowtail pupae. (×2.2)

beneath the spiracles of the abdominal segments.

Before long the dorsum of the thorax splits and, by wriggling, the emerging pupa (figure 42) shifts the larval skin back toward its posterior end where it remains like a crumpled stocking. The pupa remains attached by the cremaster and surrounded by the yoke, but is otherwise naked and devoid of any cocoon. The pupa is characterized by several horn-like projections at the head end, and is mottled light to dark brown with thin black streaks. The wing pads are relatively short, extending down to about the third abdominal segment, and all appendages are attached their whole length to the body.

Soon the dorsum of the pupa splits and the adult emerges. However, the pupal instar may occupy a considerable length of time as this is the overwintering stage. In summer the pupal stage occupies about two weeks. When the adult crawls out of the pupal skin the wings are moist and crumpled. The adult may remain motionless for an hour or more, holding onto the pupal skin with its legs. By exerting its blood pressure, the adult extends the wings into broad, thin, and delicate organs of flight (figure 43). The wings are the most obvious and contrastingly marked feature of the adult swallowtail. The wing span is 100 mm. The markings of the wings are deep or light yellow and black. On the anal angle of the hind wing two of the inner cells have a mark of light blue scales with a patch of reddish-orange scales near the wing margin. In the anal area also is an extension of one of the anal veins into a tail-like structure, superficially resembling that of certain of the swallows, which suggested the common name of swallowtail. Dorsally the butterfly has a broad black mark extending down the thorax and abdomen, and bordering this are the sides of yellow. The antennae, like other butterflies, have the tips dilated into a slight knob.

According to Comstock (1927) adults are flying from early spring to late fall, indicating perhaps continuous breeding and overlapping broods. At least two broods occur annually.

In the few cases where insecticidal control of this larva is necessary, DDT, or other chlorinated hydrocarbon insecticides, or Sevin (carbaryl), will be suitable. See section on control.

Fig. 43. Pinned and spread western swallowtail adult. (×1.1)

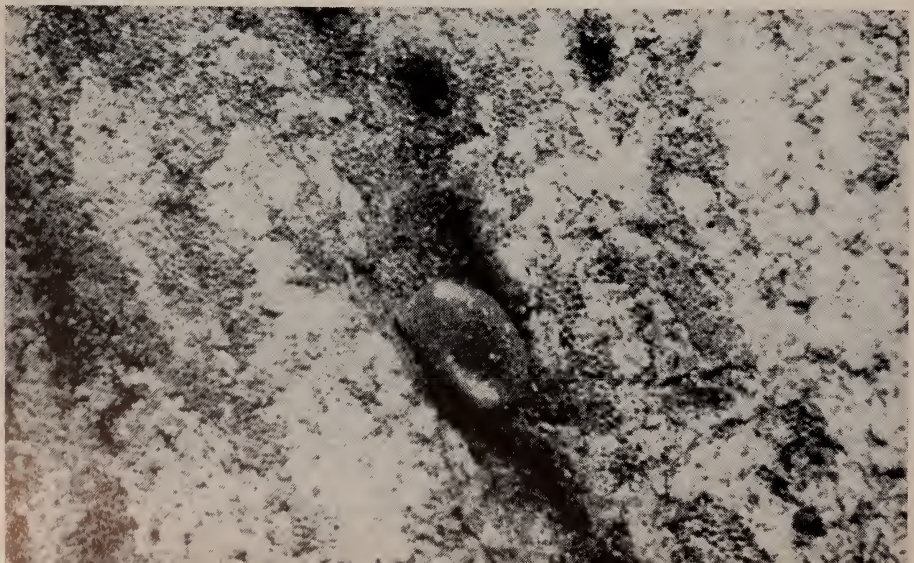
BORING INSECT

Western sycamore borer

The western sycamore borer, *Ramosia resplendens* (Edwards), (Lepidoptera: Aegeriidae), is one of the most common of sycamore pests. The authors have reported on this insect as it affects the oak tree (Brown and Eads, 1965), and much of the following is adapted from that publication. Usually an infestation of the western sycamore borer is first suspected by the presence of a reddish sawdust-like material (frass) around the base of the tree, or in the crotches of the major limbs. This is the fecal material that the boring larva has expelled from its tunnel. Often several years pass before an infestation is noticed; by this time the bark has become considerably roughened. When this roughened bark is scraped away (figure 44), numerous meandering tunnels of the borer are exposed that may be partially filled with frass. Older tissue, slow-growing tissue, or injured tissue seem to be sites favored for attack, such as that on older trees, or in a limb crotch or beneath a limb base or above a wound where an automobile has bumped or where cultivating equipment has cut the bark. The borer is primarily a bark feeder, but frequently tunnels down into the cambium layer. Usually only the lower part of the sycamore tree (up to about 30 feet) is attacked, but under repeated and severe infestations it will attack higher in the

Fig. 44. Sycamore trunk bark scraped to expose numerous meandering tunnels made by larvae of borer. (×0.36)

Fig. 45. Egg of borer, laid in small crack of trunk bark. (×25.8)



tree. It is difficult to assess the overall effect of these borer infestations on the sycamore tree, but it is likely that in heavy infestations the growth of the tree is retarded. Compared to the normal, healthy trunk and limb bark of the sycamore the roughened, infested, and frass-covered bark is unsightly. Control measures are probably warranted, particularly on single specimen trees, or the few trees in a home yard. The insect is common throughout California, and we have seen it and its depradations many times in southern California on the various species of sycamore there, and also on coast liveoak.

The commonly available literature (Essig, 1926; Doane *et al.*, 1936; Herbert, 1936; McDunnough, 1939) gives the scientific name of the western sycamore borer as either *Aegeria mellinipennis* or *Synanthedon mellinipennis,* with *resplendens* of Edwards either not mentioned or listed as a synonym of *mellinipennis* of Boisduval. According to Engelhardt (1946), whom we are following, this is in error in that *mellinipennis* Boisduval is a rare species attacking only ceanothus. The common aegeriid attacking the sycamore tree is *Ramosia resplendens* (Edwards).

The egg (figure 45) is 0.8 mm long, oval, golden, and slightly net-like on the surface. At maturity the larva (figure 46) is 18 mm long, without conspicuous hairs, pinkish-white to dark pink; the head capsule is reddish-brown. The pupa (figure 47) is 10 mm long, shining mahogany brown, and darker under the segmental combs. Abdominal segments seven and eight are constricted and darker dorsally. The eyes and front are darkened near maturity. The pupa is found in a dirty white silken cocoon which incorporates considerable frass on the outside; the cast larval skin is also in the cocoon. Wing span of the adult (figures 48 and 49) is 23 mm. The head and antennae are blue-black, and the palpi and collar are yellow. The thorax is blue-black, with nearly parallel yellow lines on the sides of the mesonotum. The forewing veins are iridescent blue-black, and the apical cells have yellow scales. There is an elongate, basal, triangular, and transparent area and sub-circular, transparent area apically. The hind wing is completely transparent; it has a brownish-black fringe with inner yellow scales. Dorsally the male abdomen (figure 48) has the first segment black, segments two, four and six are yellow and black, and segments three and five are black and slightly yellow. The fan or brush (posterior hairs around the genitalia) is black, slightly yellow in the center and on the sides. Dorsally the female abdomen (figure 49) has segments one and three blue-black and all others yellow; the brush is yellow with a slight amount of black in the center.

The western sycamore borer has only a single brood per year; the moths emerge and fly from May to early August depend-

Fig. 46. Larva of borer removed from its tunnel and placed on piece of bark. (×4.4)

Fig. 47. Cocoons and pupae of borer removed from their tunnel. (×3.0)

ing on the area and mean temperature (the higher the temperature, the earlier in the year emergence will occur). Peak emergence is in June and July. Other than at times of emergence and oviposition the adults usually are found on or about the leaves near the top of the tree. The eggs are laid soon after emergence, singly, and in a small crack or depression or against some irregularity of the trunk bark (figure 45); this is typical of the family. The larva hatches, bores in and begins a tunnel in the bark or cambium area. This tunneling continues into the following year, and the tunnel is expanded to accommodate larval growth. Tunnels are somewhat serpentine in shape, with the larva often doubling back on itself in feeding. Injury (or mine) from one larva covers an area measuring approximately 4×4 inches. Two larvae seldom use the same mine except when the infestation is very heavy; then the mines may meet or overlap. A mine with a larva working in it is damp whereas a mine that the larva has left is dry.

Just prior to pupation the larva bores almost to the outside of the bark leaving only a paper-thin layer of bark epidermis and crawls back into the tunnel a few inches to pupate. When time of emergence approaches, the pupa, by vigorous wriggling, bursts through the cocoon, and with the aid of the rear-directed segmental spines, or combs, propels itself through the tunnel and through the thin bark layer. When about one-half to two-thirds of the pupa is protruding from the bark, the dorsum of the thorax splits and the adult quickly emerges. The newly-emerged moth is soon ready for flight after rapid expansion of the wings. Not only does this species mimic some of the wasps in coloration but its actions are wasp-like, with intermittent rapid running and fluttering of the wings. However, the moth cannot sting or bite and is quite harmless to humans.

Several methods of control of the western sycamore borer have been tried with varying success. Some degree of larval kill has been attained by scraping off the rough bark and painting on a saturated solution of paradichlorobenzene (PDB) in linseed oil (Smith, 1944). The wrapping of the treated area with burlap sacks increased the larval kill, probably because the PDB in gaseous form became more concentrated in the tunnels. The

Fig. 48. Living adult male borer and pupal skin. (×3.0)

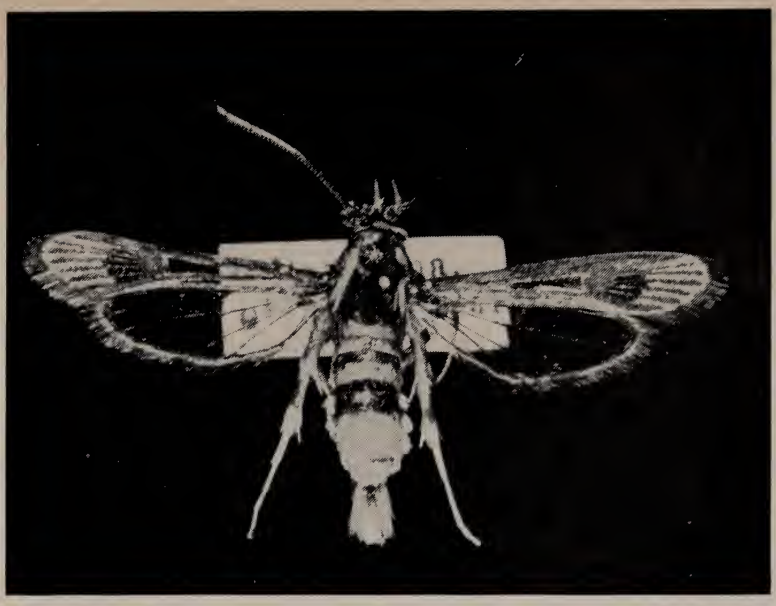


Fig. 49. Pinned and spread adult female borer. (×3.6)

use of PDB in linseed oil is probably most effective either in the spring or fall and is practical only on single specimen trees or a few trees at most. As with other boring insects, and especially with aegeriid borers, it is desirable to maintain the vigor of the sycamore by judicious watering, fertilizing and pruning and whatever corrective tree surgery is needed. To kill the adults after emergence, usually in late May or in June, depending on the area, it is possible to paint or spray the affected trunk areas (do not use on the foliage) with a high concentration of DDT. For spraying or painting a slurry on the trunk areas only, a concentration of DDT equivalent to 2 pounds of active ingredient, or more, of insecticide per 100 gallons of water may be used. For spraying the foliage and the trunk DDT or Sevin at the rate of 1 pound of active ingredient per 100 gallons of water may be used; use only ½ pound of active ingredient of dieldrin for such a spray. At the first sign of pupal skins protruding from the trunk bark area insecticide control measures should be applied. See section on control .

CONTROL OF SYCAMORE PESTS

The following recommended insecticide dosages for the control of sycamore pests are listed roughly in the order of length of experience with the material, and also according to its insecticidal effectiveness, and its harmfulness to plants and higher animals. No doubt some materials lower on the list will replace materials higher on the list when more is learned of their use. Consult the section on a specific insect for timing of sprays. All dosages are amounts per 100 gallons of water or, more accurately, 100 gallons of finished spray. Unless otherwise stated, all recommendations are for thorough-coverage, conventional, high-pressure spraying.

Precautions in the use of insecticides

Always read the insecticide package label, for directions for use, as well as precautions to be followed. If directions on the label differ from these recommendations, follow the directions on the label. Avoid inhaling the dust particles of a wettable powder formulation. If an emulsifiable formulation is spilled on the skin, it should be removed immediately with soap and water; or if splashed in the eyes, they should be flushed several times with a large quantity of clean water. Have the address of a nearby medical doctor who is familiar with the diagnosis and treatment of insecticide poisoning. Remove all empty insecticide containers from the client's property, and rinse, crush, and bury the containers at the city dump. There is less chance of injuring the sycamore leaves with insecticides if the tree has been well irrigated a couple of weeks prior to spraying. If smog concentration is high it is probably better to postpone the spraying until it is lower. If the sycamore is near a fish pond, one or more of the following measures will help prevent insecticide injury to the fish: (a) avoid spraying over the pond; (b) cover the pond with a plastic sheet; and (c) remove the fish to a safe place and drain the water. Children and pets (and feeding dishes of the latter) should be excluded from the sprayed area during spraying operations and until the spray residue has dried on the tree. Store insecticides where they are not accessible to children, irresponsible persons, or pets—preferably under lock and key. Store insecticides where they cannot be confused with food. Never put insecticides in a container that is normally associated with food, such as a soft drink bottle.

WARNING ON USE OF PESTICIDES

These recommendations for pest control are based on the best information currently available for each pesticide listed. Treatments based upon these recommendations should give adequate control and not cause any serious hazard if the applicator follows all directions on the insecticide package label with respect to dosage levels, number of applications, and precautions for the user as well as those for fish and other wildlife.

The applicator is legally responsible for treatments on a given property as well as for problems caused by drift from original property to other properties or crops.

INSECTICIDE DOSAGES FOR CONTROL OF SUCKING INSECTS

Insecticide and formulation	Dosage/100 gal water	Remarks
1. Oil, dormant, flowable or emuls.	4 or 5 gal	Winter treatment of scales
2. Oil, light medium	3 gal	Winter treatment of scales
3. Oil, light medium, *plus* Malathion emuls. conc. (8 lb/gal), *or* wett. powd. (25%)	1½ gal 1½ pt 4 lb	Scales
4. Oil, light medium, *plus* Diazinon, emuls. conc. (8 lb/gal), *or* wett. powd. (50%)	1½ gal 1 pt 1 lb	Scales
5. Malathion, wett. powd. (25%), *or* emuls. conc. (8 lb/gal)	 4 lb 1 pt	All sucking insects; time for scale crawler hatch
6. Diazinon, wett. powd. (50%), *or* emuls. conc. (4 lb/gal)	 1 lb 1 pt	All sucking insects; time for scale crawler hatch
7. DDT, wett. powd. (50%)	2 lb	Leafhoppers
8. Sevin (carbaryl), wett. powd. (50%)	 2 lb	Leafhoppers
9. Kelthane, wett. powd. (18.5%), *or* emuls. conc. (1.5 lb/gal)	 2 lb 1 qt	Mites
10. Tedion, wett. powd. (25%)	1 lb	Mites

INSECTICIDE DOSAGES FOR CONTROL OF LEAF-CONSUMING INSECTS

Insecticide and formulation	Dosage/100 gal water	Remarks
1. DDT, wett. powd. (50%)	2 lb	Time for miners; others when seen
2. Sevin (carbaryl), wett. powd. (50%)	 2 lb	Same as above
3. Malathion, wett. powd. (25%) emuls. conc. (8 lb./gal)	 4–6 lb 1–2 pt	Same as above
4. Diazinon, wett. powd. (50%)	1 lb	Same as above

INSECTICIDE DOSAGES FOR CONTROL OF BORING INSECTS

Insecticide and formulation	Dosage/100 gal water	Remarks
1. DDT, wett. powd. (50%)	2 lb	Time for adult emergence
	(slurry)	Same as above; affected area only
2. Dieldrin, wett. powd. (50%)	1 lb	Time for adult emergence
3. Sevin (carbaryl), wett. powd. (50%)	2 lb	Time for adult emergence
4. Paradichlorobenzene (PDB), saturated solution in linseed oil		For larvae; paint on affected area after scraping away roughened bark; covering painted area with burlap sack helps

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